DEVICE AND METHOD FOR DISPLACING GAS TURBINES, ESPECIALLY DURING MAINTENANCE

[0001] The present invention relates to devices for displacing gas turbines, i.e., aircraft engines or stationary gas turbines or modules of a gas turbine, in particular during maintenance of same, and the corresponding method.

[0002] Maintenance and service of gas turbines, in particular aircraft engines, have a decisive role in determining the direct operating costs of an airplane. Thus, approximately 30% of the direct operating costs of an airplane is attributable to engines, approximately one-third of the operating costs relating to the engines being due to the maintenance of the aircraft engines. The maintenance costs of aircraft engines are therefore responsible for approximately 10% of the total direct operating costs of an airplane. The direct consequence of this is that efficient and cost-effective maintenance and servicing/repair of aircraft engines is of decisive importance for airlines. Similar reasoning applies also to stationary gas turbines.

[0003] To date, maintenance and servicing of gas turbines, in particular of aircraft engines, have been performed according to the workshop principle. According to the workshop principle, at least portions of the gas turbine or aircraft engine remain in one position, i.e., in one location. Necessary work materials, tools, and personnel are brought to the gas turbine or aircraft engine in a timely manner, so that disturbances are kept to a minimum, and a promised maintenance time is able to be observed.

[0004] However, maintenance or servicing of gas turbines and aircraft engines according to the workshop principle has the disadvantage that maintenance does not follow a defined process structure. Instead, work on gas turbines is performed in almost any desired sequence, which results in disturbances and delays during servicing, in particular when a plurality of gas turbines or aircraft engines is being serviced simultaneously. Therefore, maintenance according to the workshop principle has the disadvantage that not only is there no clear process structure, but also long times are needed for servicing and maintenance. This has a negative effect on maintenance efficiency.

[0005] Efficient displacement is also desirable in the manufacture of new gas turbines.

[0006] On this basis, the object of the present invention is to provide a novel device and a corresponding method for displacing gas turbines or gas turbine modules.

[0007] This object is achieved by a device having the features of Patent Claim 1. According to the present invention, the device is used for displacing gas turbines or gas turbine modules, in particular during their maintenance. The device according to the present invention has at least one conveying device, the or each conveying device being raisable and lowerable in such a way that in the raised state of the or each conveying device, gas turbines or their modules are movable by moving the or each conveying device.

[0008] The device according to the present invention for displacing gas turbines or gas turbine modules, in particular during maintenance, allows maintenance or servicing to be performed according to an assembly line principle. It is a basic finding of the present invention that the assembly line principle is also suitable for maintenance work or servicing work on gas turbines. The device according to the present invention makes high efficiency and short maintenance times possible when servicing gas turbines or aircraft engines. The device according to the present invention may also be used in the manufacture of new aircraft engines.

[0009] According to an advantageous refinement of the present invention, the or each conveying device is integrated into a floor of a workshop, at least portions of the or each conveying device protruding over a plane defined by the floor in the raised state. In the raised state, the or each conveying device raises at least one gas turbine or gas turbine module to be moved, the or each gas turbine to be moved or the or each module being movable by moving the or each conveying device through a plurality of consecutive work stations.

[0010] According to an advantageous embodiment of the present invention, the or each conveying device moves the or each gas turbine or module in a cycle through the consecutive

work stations. The or each conveying device moves discontinuously.

[0011] An alternative embodiment of the device according to the present invention for displacing gas turbines or modules of aircraft engines is defined in Patent Claim 8.

[0012] The methods according to the present invention for displacing gas turbines or gas turbine modules are defined in independent Claims 15 and 16.

[0013] Preferred refinements of the present invention result from the subclaims and the description that follows.

[0014] Exemplary embodiments of the present invention are explained in more detail on the basis of the drawing without being limited thereto. In the drawing,

[0015] Figure 1 schematically shows a perspective side view of a device according to the present invention for displacing an aircraft engine module during its maintenance according to a first exemplary embodiment of the present invention;

[0016] Figure 2 shows a cross section of a detail of the device according to the present invention according to Figure 1 in a first state;

[0017] Figure 3 shows the detail of Figure 2 in a second state;.

[0018] Figure 4 shows a longitudinal section of a device according to the present invention for displacing an aircraft engine module during its maintenance according to a second exemplary embodiment of the present invention;

[0019] Figure 5 shows a longitudinal section of a device according to the present invention for displacing an aircraft engine module during its maintenance according to a third exemplary embodiment of the present invention; and

[0020] Figure 6 shows the device of Figure 4 in a second state.

[0021] The present invention proposes devices for displacing gas turbines or gas turbine modules and is described below using aircraft engines as an example. The present invention thus makes it possible to establish an assembly line principle for maintenance, servicing, or repairs of aircraft engines or their modules. It should be pointed out again that the devices and methods according to the present invention may also be used in the manufacture of new aircraft engines or aircraft engine modules.

[0022] For servicing or maintaining an aircraft engine, the aircraft engine is taken apart, i.e., disassembled, into modules, namely into a low-pressure turbine module, a high-pressure turbine module, a high-pressure compressor module, a fan case module, and subsequently the modules are taken apart into subassemblies and individual parts. The modules, subassemblies, or individual parts are taken for inspection and repair after disassembly. Following repair or inspection, the aircraft engine or aircraft engine modules are assembled from repaired and/or inspected and/or new subassemblies and individual parts.

[0023] The present invention relates to the provision of a device for displacing the modules of an aircraft engine during disassembly into subassemblies or individual parts and during assembly of the modules. Although the device according to the present invention theoretically could also be used during disassembly of the entire aircraft engine into modules, the exemplary embodiments which are described in detail below are directed to the disassembly and assembly of the aircraft engine modules.

[0024] Figures 1 through 3 show a first embodiment of a device 10 according to the present invention for displacing modules of aircraft engines during their maintenance. Thus, Figure 1 shows a fan case module 11 of an aircraft engine. Fan case module 11 is held by a total of four props 12, two props 12 being situated on one side of fan case module 11, and all four props 12 being mounted on a platform 13. Props 12 and platform 13 form an adapter, which may be adapted to different fan case modules of different aircraft engines. The position of props 12 on platform 13 may thus be modified. A variety of different fan case modules may

thus be accommodated.

[0025] According to Figure 1, fan case module 11, positioned on platform 13 and supported by props 12, stands on a floor 14 of a workshop. Two conveying devices 15, 16 are integrated into floor 14 of the workshop. The two conveying devices 15, 16 are approximately parallel to one another. Conveying devices 15, 16 may be raised or lowered. In the raised state of conveying devices 15, 16, at least portions of same protrude over a plane formed by floor 14 of the workshop. Platform 13 and fan case module 11 are thus raised from floor 14. In the raised state of conveying devices 15 and 16, fan case module 11 is movable via the movement of conveying devices 15, 16. The movement takes place in a main conveying direction through a plurality of consecutive work stations, fan case module 11 being taken apart, i.e., disassembled, into subassemblies or individual parts at the consecutive work stations. Of course, a fan case module 11 may also be put together, i.e., assembled, from individual parts or subassemblies at the work stations.

[0026] The design principle and mode of operation of conveying devices 15 and 16 are elucidated below in greater detail with reference to Figures 2 and 3. Figure 2 shows conveying device 15 or 16 in a raised state; Figure 3 shows the same in a lowered state.

[0027] According to Figures 2 and 3, conveying device 15 or 16 is integrated into floor 14 of a workshop. For this purpose, a vertical shaft or slot 17 is made in floor 14, conveying device 15 or 16 being mounted in this slot 17. Conveying device 15 or 16 is designed as a chain conveyor 18. A chain conveyor 18 of this type has a revolving conveying chain; a section 19 of same, running in the main conveying direction of the conveyor chain, runs in an upper section of slot 17, and a section 20 of the conveyor chain, running in the opposite direction of the main conveying direction, is positioned in a lower section of the slot. Thus, Figures 2 and 3 show that section 20 of chain conveyor 18, running opposite to the main conveying direction, is fixedly mounted in a housing 21, housing 21 being adjacent to a lower section of slot 17.

[0028] Upper section 19 of chain conveyor 18, running in the main conveying direction, is

raisable and lowerable according to Figures 2 and 3. For this purpose, upper section 19 of chain conveyor 18, running in the main conveying direction, is situated on a pneumatic cylinder 22. Pneumatic cylinder 22 is guided in a housing 23.

[0029] In the exemplary embodiment shown, two C hoses 24, 25, into which compressed air may be introduced, are situated in pneumatic cylinder 22. Figure 2 shows C hoses 24 and 25 in the state filled with compressed air, while Figure 3 shows the two C hoses 24, 25 in the emptied state. According to Figure 2, in the state of C hoses 24 and 25 filled with compressed air, section 19 of chain conveyor 18, running in the main conveying direction, is raised over a plane formed by floor 14 of the workshop. Portions of section 19 of chain conveyor 18 then protrude over floor 14. In the emptied state of C hoses 24 and 25 (see Figure 3), chain conveyor 18 is fully lowered below the plane formed by floor 14.

[0030] According to the present invention, conveying device 15 or 16 is raised over the plane formed by floor 14 of the workshop only in a cycle of sixteen or twelve hours, i.e., discontinuously. Conveying device 15, 16 of chain conveyor 18 is moved in the raised state every sixteen or twelve hours in such a way that fan case module 11 is displaced by one work station. Within the cycle, fan case module 11 remains within the particular work station, and conveying device 15, 16 is in the state shown in Figure 3.

[0031] Unlike the embodiment shown in Figures 2 and 3, conveying device 15, 16 may also be raised and lowered in different ways. Thus, instead of pneumatic cylinder 22, a hydraulic cylinder may be used. Conveying device 15, 16 may also be lowered and raised using an eccentric or an inclined plane.

[0032] After lowering chain conveyor 18 into the position shown in Figure 3, slot 17 is preferably covered with a cover, which is not illustrated, flush with the floor. This ensures that rolling trucks or hand elevating trucks or similar devices may travel on floor 14 in the area of each work station. It is furthermore ensured that tools or individual parts of fan case 11 are prevented from falling into slots 17 during assembly or disassembly work. Furthermore, work safety is enhanced, since the worker moving in the area of the work

station is prevented from stepping into the slot. Slot 17 may be covered with the cover (not shown) manually, because the cover must be placed and removed only according to the cycle of the displacement, which takes place every sixteen or twelve hours.

[0033] Figures 4 through 6 show longitudinal sections of two exemplary embodiments of an alternative device for displacing aircraft engine modules, the two exemplary embodiments differing only with respect to the number of work stations through which the module(s) is(are) to be moved. Thus, Figures 4, 6 show two consecutive work stations 26 and 27, while Figure 5 shows a total of four consecutive work stations 28, 29, 30, and 31. The exemplary embodiment according to Figures 4, 6 having two work stations is preferably used when disassembling an aircraft engine module, and the exemplary embodiment according to Figure 5 is preferably used when assembling the module. It should be pointed out here that no aircraft engine module is shown in Figures 4 through 6. The exemplary embodiments of Figures 4 through 6 are, however, well-suited in particular for moving a high-pressure compressor module of an aircraft engine.

[0034] As mentioned previously, since both exemplary embodiments of Figures 4 through 6 only differ with respect to the number of work stations, the same reference numerals are used for the same subassemblies in order to avoid repetition.

[0035] Thus, Figures 4, 6 show a longitudinal section of device 32 according to the present invention for displacing a high-pressure compressor module from the aircraft engine for maintenance; device 32 according to Figures 4, 6 is to move the high-pressure compressor module through the two consecutive work stations 26 and 27. A conveying device 34 is integrated in a floor 33 of a workshop between the two work stations 26 and 27; if there are more than two consecutive work stations, as in the exemplary embodiment of Figure 5, conveying device 34 connects all work stations. Conveying device 34 is designed as a chain conveyor and is integrated into floor 33 of the workshop in such a way that its vertical relative position to a plane formed by floor 33 of the workshop is fixed. In other words, this means that conveying device 34 designed as a chain conveyor is not raised or lowered.

[0036] Holding devices 37, i.e., module carriers, may be suspended or snapped or coupled into conveying device 34 designed as a chain conveyor. The high-pressure compressor modules to be moved are positioned on holding devices 37. When chain conveyor 34 is moved in the main conveying direction, holding devices 37, snapped into chain conveyor 34, are drawn, preferably rolled over floor 33 of the workshop. The holding devices are therefore provided with rollers, which enables them to roll on floor 33.

[0037] As in the case of the device of Figures 1 through 3, in the devices according to Figures 4 and 5 the chain conveyor also works discontinuously, i.e., the modules to be serviced are moved in a cycle through the consecutive work stations.

[0038] In the case of the devices of Figures 4 through 6, a lifting device 35 is situated in the area of each work station. With the aid of lifting device 35, a high-pressure compressor module of an aircraft engine moved into a work station, together with the respective holding device 37, is raisable over the plane defined by floor 33 or lowerable below this level.

[0039] The upward motion of lifting devices 35, which are preferably hydraulically operated, is indicated by an arrow 36. Lifting devices 36 are raised and lowered while conveying device 34 is immobilized. With the aid of lifting devices 35, the high-pressure compressor module to be serviced may be moved into a position that is comfortable for the worker.

[0040] A gap in the area of lifting devices 35 is again covered by a cover, in particular by a brush segment, so that no tools or individual parts may fall into the gap. The cover is adapted to the different modules of the different aircraft engines.

[0041] Using the above-described devices for displacing aircraft engine modules, the assembly line principle may be used for servicing the modules. The modules are moved through consecutive work stations, different work steps being performed on the modules at the consecutive work stations.

List of Reference Numerals

Device	10
Fan case module	11
Prop	12
Platform	13
Floor	14
Conveying device	15
Conveying device	16
Slot	17
Chain conveyor	18
Section	19
Section	20
Housing	21
Pneumatic cylinder	22
Housing	23
C hose	24
C hose	25
Work station	26
Work station	27
Work station	28
Work station	29
Work station	30
Work station	31
Device	32
Floor	33
Conveying device	34
Lifting device	35
Arrow	36
Holding device	37